DESPITE PLN'S IMPROVED RELIABILITY, OUTAGE COST TO INDUSTRY REMAIN HIGH

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Pertumbuhan ekonomi yang cukup tinggi di Indonesia selama sepuluh tahun terakhir telah membawa dampak pada peningkatan tajam permintaan energi listrik dari seluruh sektor perekonomian. Konsekuensi logis dari hal tersebut adalah dituntutnya penyediaan energi listrik dalam mengimbangi pertumbuhan permintaan tersebut untuk menjaga momentum pertumbuhan yang sudah ada.

Studi ini mencoba melihat perkembangan kemampuan PLN (Perusahaan Listrik Negara) dalam menyediakan energi listrik, khususnya bagi industri manufaktur selama sepuluh tahun terakhir. Hasil studi ini menunjukkan beberapa hal penting yang sangat relevan bagi PLN maupun industri sebagai bahan referensi dalam menentukan kebijakannya. Pertama, *meskipun keandalan PLN dalam menyediakan listrik semakin baik, namun biaya yang harus ditanggung oleh industri manufaktur akibat padamnya listrik semakin tinggi.* Kedua, *permintaan energi listrik tampak meningkat, namun penyediaan listrik PLN masih kurang mampu mengimbangi pertumbuhan permintaan. Hal ini menyebabkan industri membangkitkan listrik sendiri, meskipun dengan efisiensi yang lebih rendah.*

Kedua hasil penelitian ini memberikan implikasi kebijakan yang penting bagi PLN khususnya, yaitu pertama, *PLN harus terus berusaha beroperasi dalam skala yang semakin efisien dan* kedua, *perlunya kebijakan permintaan (demand side management) dalam upaya konservasi energi dan mengantisipasi waktu peak penggunaan listrik. Satu hal yang patut digarisbawahi adalah bahwa implikasi kebijakan di atas bukanlah merupakan paradoks yang akan menurunkan pendapatan PLN, tetapi melalui manajemen sisi permintaaan yang tepat, penurunan pendapatan PLN yang dikhawatirkan diharapkan bisa dicegah dan momentum pertumbuhan ekonomi bisa tetap terjaga.*

Keywords: electricity; PLN; Indonesia; reliability; outage cost

Introduction

The power sector is a vital component of a country's economic development. Economic growth and industrial productivity all depend to some degree on performance of this sector. Many developing countries, unfortunately, are plagued by power shortages and an unreliable electricity service.

Because of this, many industries purchasing power from an electric utility also generate some of their own electricity to guarantee an adequate, uninterrupted supply of electricity. Whether an outage is planned or unplanned, since doing without electricity, is not acceptable, such industries are willing to pay for a generator to "stand by" to provide power as needed (Zakem, 1988). The combination of utility-generated power[1] and power generated by the industry itself then provides virtually full availability and reliability[2]. In recent years, the industrial sector has shown greater interest in self-generating plants, in the hope of achieving an adequate, reliable service. In general terms, self-generation refers to the production of electricity by an industrial firm[3]. The firm may either meet its remaining electricity needs by purchasing from a utility or, if the firm produces a surplus, sell to the utility at a prearranged rate.

In practically all developing countries, the majority of electric utilities are state-owned (Bernstein and Hegazzy, 1988). As the economy and population grow, problems of electricity shortages and reliability become issues in developing countries. For these reasons, industrial firms increasingly turn to self-generated power to provide electricity of the quantity and quality they demand. Among the reasons industrial firms consider self-generated power as an alternative to purchasing utility-generated electricity are the possible comparative cost advantage in terms of the prices of other energy sources (electricity, natural gas, coal, etc.), and the reliability of the utility.

These factors will vary in significance according to the specific conditions of a given firm. This study, however, does not attempt to address the firm's decision, but rather, it investigates the capability of the Indonesian State Power Utility (PLN) to provide a reliable electricity service. Thus, this article will deal extensively with analysis of the issues revolving around the following questions: What is PLN's track record in providing a quality electricity service in line with customer demand? What would be the impact of PLN unsupplied electricity or a power blackout? What has been the trend over the last ten years? What is PLN's strategy to ensure a reliable electricity service?

Analytical and empirical application of an economic based model will be employed to address all of these issues. An input-output analysis is use to estimate the reliability of PLN service. Part II presents a review of growth in the market share of PLN-generated power, in the consumption of electricity by industry, and in captive power generators. Part III reviews

[1] Utility power is associated with electricity service which is government owned.

[2] Reliability of power service can be increased in several ways, which include technical and economical aspects. Given that the technical conditions of the plants (generation, transmission, and distribution) will remain the same in the short or medium term, the level of reliability can be improved by providing the supply of electricity continuously.

[3] In general terms the self-generation plant may or may not be a cogeneration process. In this study, it refers to self-generated electricity by firms.

several similar studies and literature related to the study, providing a background for the models presented in the following part. Part IV focuses on the methodology and data used. The main objective of this part is to investigate the impact of a PLN power blackout (outage cost) and important pointers to improve the reliability of PLN service. Part V analyzes the results and considers policy implications .

Development of the Power Sector in Indonesia

The reasonably high rate of economic growth in Indonesia throughout Pelita V, averaging 7.9 percent p.a., has affected all sectors of the economy. With increasing demand for fuel, this growth has had a substantial impact on the energy sector. On the other hand, the supply of renewable and non-renewable energy is relatively limited. These two phenomena are ongoing central issues in a number of countries (Howe, 1979).

Electricity Supply and Demand

Since electricity is one form of energy which can be used by almost all sectors of the economy, demand has grown rapidly. As predicted, for the period 1990-1995, the household and industrial sectors used most electricity in terms of both final consumption and as an input or factor of production.

In 1990, consumption of electricity by households stood at 8,877.2 GWH, jumping 5 years later to 14,376.11 GWH arise of 10.48 percent per year. Consumption in the industrial sector, the major user of electricity, also grew over the same period. In 1990, this sector consumed 26,912.5 GWH of electrical energy, rising to 44,676.67 Gwh in 1995, or annual growth in demand of 6.58 percent (Table 1).

On the supply side, the amount of electricity generated by PLN has also grown. Table 2 shows the growth in installed capacity of PLN owned generators, 1990-1995.

The 1990-1995 period saw somewhat significant change in the installed capacity of the different types of PLN-owned generators. This came about because of government moves through PLN to reduce dependency on oil as the primary fuel for electricity generation. Table 2 shows that the role of PLTD(diesel power plant) and PLTA (hydro) is falling, and while the role of PLTU and PLTGU (non-oil fired) is rising. In the light of domestic scarcity of oil, this move by PLN seems rational.

Table 1. **Ectricity Consumption by Sector**

Year	Household	Industry	Household and Industry
1990	8,877.2	32,480.28	41,357.48
1991	9,776.4	33,211.66	42,988.06
1992	11,198.92	42,606.89	48,533.02
1993	12,537.8	36,995.22	49,533.02
1994	14,460	44,022.26	58,482.26
1995	14,376.11	44,676.67	59,052.27

Source: BPS Indonesia Energy Balance, calculated

Table 2. **Installed Capacity by Generator Type**

Type of Generator	1990		1995	
	Installed Capacity*		Installed Capacity*	
	MW	%	MW	%
PLTD (Diesel)	1,870	20.50	2,250	15.02
PLTU (Steam)	3,941	43.21	4,821	32.18
PLTA (Hydro)	2,095	22.97	2,177	14.53
PLTG (Gas Turbine)	1,073	11.76	3,004	6.70
PLTP (Geothermal)	140	1.56	307	2.05
PLTGU (Stem Gas)	-	-	4,422	29.52
Sum	9,119	100	14,981	100

* Installed capacity is the capacity of one generating unit as written on the generator nameplate or on the prime mover, which is smaller

Source: BPS, Indonesia Energy Balance, 1995

Table 3. **Gross PLN Electricity Production (GWH)**

Generator	1990	1991	1992	1993	1994	1995
PLTD (Diesel)	3,606	3,660	3,929	4,136	4,246	4,828
PLTU (Steam)	21,465	23,785	23,377	21,963	21,582	21,582
PLTA (Hydro)	5,890	5,973	8,572	7,835	6,878	6,878
PLTG (Gas Turbine)	2,360	2,581	2,553	2,807	1,005	1,005
PLTP (Geothermal)	1,125	1,102	1,025	1,008	1,601	1,601
PLTGU (Steam Gas)	-	-	984	6,412	14,239	14,239
Sum	34,446	37,101	40,440	44,241	49,551	49,551

Source: BPS, Indonesia Energy Balance, 1995

Behind PLN's 'success' in shifting the primary energy source to non-oil fuel lies a level of demand for electricity from the household and industrial sectors which PLN is unable to meet. The data in Table 3 shows that for the period 1990-1995, PLN was unable to meet demand with the limited amount of power generated by existing power stations (compare with Table 1).

Gross production shown in the Table 3 includes consumption by auxiliary stations and energy lost in distribution/transformers. Besides expansion in demand, one reason PLN is unable to meet consumption requirements is the low capacity factor of PLN power plants[4]. In 1995, the capacity factor of PLTD stood at 24.49 percent; PLTU, 48.24 percent; PLTA, 34.41 percent; PLTG, 19.34 percent; PLTP

[4] Capacity factor = Σ Gwh gross production/ (Σ Gw installed capacity *8,760 hours)*100%. Gwh gross production is the energy (Gwh) generated by the generator before deducting the energy used for own purposes (for auxiliary equipment, station lighting, etc.) or the production of electric energy measured at the generator terminal. While installed capacity is the capacity one generating unit as written on the generator nameplete or on the prime mover, which of both is the smaller.

Table 4. **Electricity Consumption By Industrial Sector (Gwh), 1990-1994**

Year	Manufacture	Mining	Construction	Other*	Total
1990	26,115	746.39	51.39	5,567.5	32,480.28
1991	26,365	883.33	161.11	5,802.22	33,211.66
1992	35,091	992.28	203.33	6,320.28	42,606.89
1993	28,298	1,250.83	204.17	7,242.22	36,995.22
1994	34,077	1,410	232.2	8,303.06	44,022.26

* Other = Agricultural, trade, hotel, restaurant, other services
Source: BPS, Energy Balance 1994

at 82.18 percent; and PLTGU at 45.89 percent. This translates as just 42.42 percent of installed capacity of these generators being used to generate electricity.

Given the current performance of PLN power stations, it would be hardly surprising if PLN's inability to improve itself leads to a domestic energy crisis, if the supply of electricity generated by PLN, non-PLN sources and industry itself fails to meet demand.

Growth in Industrial Electricity Consumption and Captive Power Generators

The share of electricity consumed by the industrial sector swells annually. In 1975, this sector accounted for 30 percent of total consumption; by 1995, the figure had jumped to around 59 percent. Between 1990 and 1995 electricity consumption in the industrial sector grew an annual 5.58 percent equal to percentage growth in GDP in Indonesia during Pelita V. Demand for electricity in the industrial sector is estimated to reach 195.917 GWH by 2014, while PLN-generated is estimated at just 180.427 GWH (assuming the 1985 capacity factor of 40 percent).

In general, the electricity consumed by the industrial sector in Indonesia derives from three sources: electricity purchased from PLN; electricity purchased from non-PLN sources; and electricity generated by firms themselves. The manufacturing industry uses more electricity than any other industry in this sector. Table 5 shows by source, proportional use of electricity by manufacturing industries.

The question which may arise is how PLN can accommodate the increasing demand of industrial sector (Bherman and Deolalikar, 1989; Schwarz, 1989). PLN's effort to meet growth in demand is reflected in a 15.82 percent annual expansion in power generated during the period 1974-1995, growing from 2,444 Gwh to 53,448 Gwh. Capacity itself grew from 922 MW to 14,981 MW, or about 14.19 percent. PLN efforts have been hampered by a population spread over vast areas. Distribution is worst on islands outside Java. Under such conditions, expanding capacity would be insufficient without a corresponding increase in transmission and distribution lines (Pratomo, 1988).

Two other factors also contribute to PLN's inability to provide the best services. *First*, lack of information concerning the locations in which industrial firms will be concentrated. The zoning policy on which a distribution plan is based often not clearly formulated by local government (Abimanyu, 1993). The outcome is unexpected growth of indus-

Table 5. **Proportional Use of Electricity by Manufacturing Industries: 1985 and 1995**

ISIC	Industry	Self-generated		Purchased from PLN		Purchased from non-PLN Source	
		1985	1995	1985	1995	1985	1995
31	Food, bev &tobacco	0.97	0.43	0.03	0.55	0.00	0.18
32	Textile	0.74	0.30	0.25	0.69	0.01	0.10
33	Wood&wood prod.	0.97	0.63	0.02	0.36	0.00	0.02
34	Paper	0.75	0.57	0.24	0.43	0.00	0.02
35	Chemical	0.81	0.36	0.18	0.62	0.01	0.17
36	Non-metal prod.	0.75	0.40	0.23	0.54	0.02	0.58
37	Basic metal	0.48	0.35	0.52	0.65	0.00	0.001
38	Machine & equip.	0.62	0.17	0.36	0.75	0.02	0.88
39	Other	0.72	0.25	0.28	0.75	0.00	0.001
	Average	0.81	3.46	0.18	5.34	0.01	2.22

Source: BPS, Large and Medium-scale Industry Statistic, 1985 and 1995

trial firms in areas where the distribution system had not been designed to accommodate industrial customers. This has created a surge in demand causing distribution system overload and consequent failure to meet that demand. *Second* is implementation of a policy eliminating import duty and tax on imported machinery destined to be used by foreign firms. This has lowered the cost of private power generation, which in turn has reduced the competitiveness of PLN-generated power.

Inadequate and unreliable grid supply led industrial enterprises to install captive generators on a large scale during the 1970's. Captive plant capacity of approximately 6,922 MW accounted for approximately 43 percent of the nation's total installed capacity, as of 1990/91.

Table 6 shows the captive generation capacity and mix in Indonesia. The predominant fuel for captive generation is diesel (82 percent in Java and 46 percent outside Java); other fuels used in significant amounts are gas (14 percent in Java) and hydro and geothermal outside Java (20 percent and 23 percent, respectively).

The estimated 6,922 MW of captive capacity is spread over approximately 10,000 units split almost evenly among Java and other areas. More than 90 percent of these installations are under 1 MVA each, and together they account for approximately 25 percent of installed captive generation capacity. On the other end of the spectrum, the 40 companies each with an installed capacity of 20 MVA or greater, together account for 3,300 MW (approximately 50 percent of national captive generation capacity). Within this segment, the generation mix is as follows: 60 percent diesel, 13 percent gas turbines, 11 percent hydro, 7 percent gas thermal, and the remaining 5 percent split almost evenly between oil thermal and wood thermal. Of the national captive generation capacity, approximately 2,000 MW are estimated to be operated in a" standby plant mode", i.e., predominantly as back up.

Table 6. **Captive Generation: Estimated Installed Capacity and Mix**

Location/ Province	Installed Capacity 1990/91 MW	Generation Capacity Mix (%), 1988/89							
				Steam					
		Diesel	Hydro	Coal	Oil	Gas	Wood	GT	Total
Java									
East	641								
Central	571								
West	1,154								
Jakarta	856								
Subtotal	3,222	82			2	14	1	1	100
Outside Java	3,700	46	20		3	0	8	23	100
Total	6,922	62	11		2	7	5	13	100

Source: PLN and Ministry of Mines and Energy Reports, 1991

Review of Related Research

The need for information concerning the value of a reliable electricity service, or, conversely, the cost of power interruptions, is apparent from even a cursory review of literature. Although the question of electric power system reliability has often been discussed in theoretical as well as empirical literature, the problem of a theoretical optimal level of reliability is yet to be resolved (see partial solutions in Panzar and Sibley, 1978; Crew and Kleindorfer, 1978; Ravid, 1979; Munasinghe ,1980; and Anderson and Taylor, 1986, among others). On the applied side, numerous studies have been produced with few conclusive results, although a cautious consensus as to the effect of reliability on the power system has surfaced. A major difficulty is in calculating the cost of unsupplied power (Munasinghe and Gellerson, 1979; Munasinghe, 1980; Bental and Ravid, 1982; Bernstein and Hegazzy, 1988; Pasha, et. al, 1989; and Sanghvi, 1991).

Many attempts have been made to calculate the outage cost of electric power. The simplest proxy approach to an estimation of outage relies essentially on fixed coefficients (Telson, 1975). It equates outage costs to the average value added per unit of energy by industry and is based on two key assumptions. *First,* that losses to industry consist only of foregone output; and *second,* that firms do not recover any of the output lost as a result of outage. According to Pasha, et al. (1989), the simplicity of this limited approach and its limited data requirements is likely to lead to a significantly biased estimation of outage cost.

Extending the proxy method to calculate the cost of unsupplied power, Bental and Ravid (1982) have made an attempt at developing a method of calculating the marginal cost of industrial power cuts. They propose that the value of unsupplied electricity for industrial purposes be measured by the cost of maintaining backup supplies. The argument behind this method is that for a profit maximizing firm, the expected gain from the marginal self-generated Kwh is also the expected loss from the marginal Kwh which is not supplied by the central utility.

Survey method approaches, rather than the proxy methods mentioned above, have been led by Munasinghe and Gellerson (1979) and Sanghvi (1982). They explicitly recognize that firms are not passive entities dependent upon market conditions, margin of excess capacity, etc., generally allowing them to recover at least part of the foregone output on condition that the benefits of doing so in terms of higher revenues more than compensate for any adjustment costs. Various types of adjustment have been identified by Munasinghe and Gellerson, including the more intensive operation of machinery and overtime.

According to Munasinghe and Gellerson's approach, there are two basic components of cost. The first comprises direct costs, which include the value of production permanently lost, spoilage costs, process restart costs, damaged machinery, etc. The second component comprises indirect costs arising from adjustments made by firms in the process of recovering output. This particular approach has been applied in Brazil (Munasinghe, 1979), Costa Rica (Munasinghe, 1984), India (Munasinghe, 1987) and Pakistan (Pasha, et al., 1989) to analyze the economic cost of outage. These are the scanty attempts to apply the latest version of the methodology for quantifying these costs on a national scale.

Realizing the problem of a lack of data for performing macro level analysis and the fact that in developing countries market distortions in the economy are caused by subsidized prices, this method has a number of complements. The macro based study by Bernstein and Hegazzy (1988) proposes an input-output formulation to measure outage cost and applies the technique to Egypt. Previous studies using the input-output approach include an application in Chile (Jaromillo and Skoknic, 1973), and a regionalized study in several developing countries by Priestman (1990).

Three major points are concluded on the basis of the review:

1. Significant progress has been made in conceptualizing and measuring the demand for service reliability, providing valuable information for use in system planning. However, the current body of literature has not kept pace with the need for detailed and accurate information in the area of innovative rate design.
2. Outage cost survey data provide the primary source of information on customer preferences for reliability. Because customers in developed countries have little experience with power interruptions, surveys may only provide information on customer attitudes and intentions toward hypothetical outages, and may not reflect how a customer would behave in the event of an actual interruption.
3. Finally, while outage cost studies have been somewhat successful in determining how preference for service reliability is affected by the duration and timing interruptions, the impact of warning, outage frequency, and partial outage have received relatively little attention.

Many studies of Indonesian electricity policy have been carried out. One to be mentioned is by McCawley (1971). He analyzes historical growth, management and organization of the public utility. The focus of this study is on pricing theory and practice. Three additional studies to be considered are by Munasinghe and

Warford (1982), Amarulah (1984, 1986) and by Mansoer (1986). The first covers the theory, implication and empirical calculation of long run marginal cost. The second analysis begins with a rigorous econometric estimation of demand, calculation of LRMC, then going on to propose a rebate mechanism to achieve growth, efficiency and distribution. Mansoer reviews and analyzes electric power pricing and investment for the Java-Indonesia inter-connected electricity system under government policy constraints. Only a few studies have been conducted based on the micro and disaggregate levels of analysis. Pitt (1982) uses cross-sectional firm data and utilizes the Translog Cost function to estimate industrial energy demand. Pratomo (1988) carried out an in-depth study into manufacturing firms' behavior in selecting electricity supply. In that study a probability model using the logistic function (Logit) was developed to determine factors affecting firm's decisions. Abimanyu (1993) uses a two stage tobit demand function to estimate firm's behavior to self-generate. This study discussed a firm's decision in choosing electric sources in Indonesia, and identified factors affecting the choice. In terms of policy implication, it is concluded that decision makers should pay more attention to the importance of improving reliability as a factor affecting a firm's choice to self-generate power.

Many studies and researches on electricity/energy decision making, especially in the manufacturing sector, have been carried out and approached using various different methods. Critiques addressing these studies in general are based on the fact that they focus on a separate analysis at either aggregate or non-aggregated/firm levels, rather than at global and integrated levels. Four complete categories of the studies and works, as previously discussed, have been carried out separately on electric power industry, on the reliability electrical service, and supply-demand imbalance as well as pricing and tariff at aggregate level. Rarely has there been a study that covers simultaneous analysis of both demand and supply. In addition, in general, these studies do not provide sufficient quantitative applied solutions and concrete policy recommendations.

This study will provide both an analysis of manufacturing firm behavior and an aggregate analysis of electricity supply. Since this is a macro-based model, the appropriate tool is input-output analysis. The conclusion will provide an alternative solution to the problem. As indicated, the problems of electricity in most developing countries, including Indonesia, are related to the imbalance of supply and demand, and a less than reliable service. The research findings, therefore, will help balance both approaches to produce better policy decisions in electricity and energy development.

Methodology and Data

Estimating Outage Costs

The input-output transaction algorithm is perhaps one of the most well-known models relating the sector gross outputs of an economy to the total final product or the units of product leaving the inter-industry system at the end of the process. This model (known as the demand driven model or Leontief model) assumes constant input coefficients and elasticity of substitution equal to zero. This model also relates the gross outputs of all sectors by specifying output exogenously (Miller and Blair, 1985). In this case, any change in the gross output of the exogenous sector will drive the changes across all sectors of the economy.

Ghosh (1958) and Augustinovics (1970) have suggested that an alternative point of view can be taken of the basic input-output data. This alternative interpretation relates sector gross production to primary inputs, that is, to a unit of value entering the inter industry system at the beginning of the process. This is called the supply-side input-output model. This approach is made operational by essentially ôrotatingö or transposing column one of the model to row one. Instead of dividing each column of Z (matrix of transaction) by the gross output of the sector associated with that column, divide each row of *Z* by the gross output of the sector associated with that row. We use *A* (technical coefficient) to denote the direct-output coefficients matrix that results. The mathematical formulation of the two models is presented below:

Z = matrix of transaction between sectors
Y = vector of sales to final demand
X = vector of total sector gross output
W = vector of the value added sector
I = column vector of ones
X^ = vector of total output being rotated becoming total input
and i = input, j = output

In supply side model, technical coefficients (a):

$$a_{ij} = z_{ij}/x_i$$

and;

$$Xt = it * Z + W$$

$$A = (x^{\wedge})^{-1} * Z$$

substituting:

$$Xt = X^{\wedge}t * \vec{A} + W$$

or

$$Xt = W\,(I-\vec{A})^{-1}$$

Given exogenously determined values for, say, changes in *W* or ΔW, we find the associated values of ΔX' as

$\Delta X' = \Delta W(I-A)^{-1}$

The basic assumption of the supply-side approach is that output distribution patterns are stable in an economic system, meaning that if output of sector *i* is, say, doubled, then one might expect that sales from *i* to each sectors that purchase from *i* will also doubled (Miller and Blair, 1985). That is, instead of fixed input coefficients, fixed output coefficients are assumed in the supply-side model. The two models studied here evaluate two types of shortages: capacity shortage and power shortage. The first, a supply side model treats electric energy as a primary input instead of an intermediate input. This model is valid for estimating outage impacts on individual sectors. The analysis highlighted the necessity of planning in a national framework, taking into account the impacts that load shedding might have on the overall economy.

Since we are concerned with electricity production and its impact on the industrial sector, consider this sector exogenously specified by deleting this sector from inter-industry matrix A. In that case, the vector of primary inputs will be augmented to include the exogenous electricity inputs. Given exogenously-determined values for a change in the availability of electricity, the associated values of gross outputs of the other sectors will be found. Then use the $(I-A_2)^{-1}$ matrix (calculated excluding the electricity sector) to evaluate the impacts of restriction on value added, i.e. electricity shortages. The sum of the rows (the input multiplier) represents the total economic impact of reductions in the value added on that particular sector. Since that type of shortage usually hits an individual area or sector by load-shedding decisions, this approach reflects only the impact of a capacity shortage on the economy.

The other model treats electricity output exogenously specified. This step aids in evaluating the costs of electricity blackouts. Given that $\Delta X' = \Delta W(I-A)^{-1}$, the impact from value added in a given sector of one rupiah, $\Delta Wi=-1$, with other sectors unchanged, will yield a negative ΔX for all sectors. This means that a drop in output in these sectors as a result of a decrease in one unit of value added input in sector *i*. In this approach, we consider the outage as it affects the entire system at once, estimating the impact of energy shortages which involve the whole economy.

Data Employed

Data are obtained from various sources. Industrial firm's time series data from the 1985-1995 Indonesian Industrial Statistics and Indonesian Input-Output Tables from 1985-1993 which are published and conducted by the national Central Bureau Statistics (BPS, Biro Pusat Statistik) comprise the main source.

The industrial statistics, published annually, contain information concerning the operations of a medium to large sample of the Indonesian manufacturing non oil establishments with 20 or more employees, particularly concerning value added and industrial power and electricity. The Indonesian industrial classification has five digits, compiled based on the International Standard Industrial Classification on economic activities (ISIC), 1968, and adjusted to local conditions. However, in order to simplify analysis, only the manufacturing industry is examined, employing two digit ISICs from ISCI 31 through ISCI 39. The manufacturing industry was chosen also because it is the leading sector in terms of value added produced. Moreover, large and medium-scale manufacturing industries consumes no less than 77 percent of total final consumption less consumption in the household sector.

To calculate the impact of an electricity outage on sectors of the economy, an input-output table was used. The 66 sector input-output table, which included components from the manufacturing industry, was first aggregated. This entailed consolidating several I-O sectors as one larger sector. In the KKI/KLUI (in-

Table 7. **ISIC and I-O Conversion**

ISIC	I-O Code	Sector/commodity
31	19, 27, 28, 29, 30, 31, 32, 33, 34	Food, beverage, and tobacco
32	35, 36	Textile
33	37	Wood and wood products
34	38	Paper
35	39, 40, 41, 42	Chemical
36	43, 44	Non-metal products
37	45, 46	Basic metal
38	47, 48, 49	Machinery and equipment
39	50	Other manufactured

Source: BPS, Indonesian Input-Output Table, 1990 dustry codes) system, this aggregation is employed automatically with regard to sub-categories, categories and on through sectors. Since data for industries categorized as ISCI 31-39 was needed for this study, data for sub-sectors of these industries categorized I-O was aggregated. Table 7 shows this aggregate of sectors in I-O. Other supporting data was derived from the 1993-1995 Energy Balance, published by BPS, and the Mining and Energy Yearbook of Indonesia, 1994, published by the Department of Mining and Energy.

Analysis of The Results

This section presents the results of the study and analysis. The first part covers general information and performance of the industrial sector, including electricity related issues, for the period 1985-1995. Discussion is limited to industry subsectors with 2-digit ISIC. The second section examines the supply and efficiency of electricity generated by industry itself, compared to that supplied by PLN. Section three considers the results of analysis of the input-output model given an electricity outage, and the final section presents general conclusions drawn from the results of the study.

General Information about the Firms and Electricity Consumption

Table 8 shows general information for the period 1985-1995 concerning 2-digit ISIC industrial firms. During this period, the manufacturing sector grew an average 18,35 percent annually. The sector experiencing the most rapid growth was other manufacturing industries (ISIC 39) at 29.67 percent, followed by manufacturers of fabricated metal products, machinery and equipment (ISIC 38) at around 24 percent. In 1995, the food and beverages industry (ISIC 31) accounted for the largest portion of total firms, at around 24.7 percent, and highest value added at 22.3 percent. ISIC 32 (manufacturers of textile, garment and leathers) had the largest share in number of employees, at about 33.7 percent.

Table 8. **Basic Data of 1985 and 1995 Manufacturing Industry (% Total)**

ISIC	1985			1995			
	Firms	Employ	Valadd	Firms	Employ	Valadd	ROG* Valadd
31	30.07	30.86	26.79	24.76	20.75	22.33	11.38
32	22.26	22.65	12.71	23.01	33.76	17.83	18.99
33	9.33	10.80	10.14	13.52	13.16	8.19	13.12
34	4.68	3.36	3.05	4.19	3.33	4.83	19.97
35	12.60	14.76	19.73	11.14	10.06	13.10	10.01
36	9.68	5.28	5.76	9.41	4.14	3.60	9.29
37	0.23	0.93	5.90	0.78	1.09	7.52	14.98
38	9.94	10.65	15.51	11.08	11.64	2.85	18.55
39	1.22	0.71	0.40	2.06	2.02	0.75	21.94
Average							15.35

Note: * ROG Value adedd per annum; Employ = Employment; Valadd = Value added
Sources: BPS, Industrial Statistics 1985 and 1995

Table 9. **Electricity Related Data of 1985 and 1994 Manufacturing Industry (% Total)**

1985						1994					
ISIC	N.gen	C.gen	S.gen	PLN	NPLN	ISIC	N.gen	C.gen	S.gen	PLN	NPLN
31	14.09	15.87	48.88	11.03	23.45	31	16.83	22.59	9.9	11.81	4.73
32	20.70	12.76	9.93	25.71	8.13	32	35.66	8.86	18.43	26.03	12.05
33	7.64	13.84	8.03	1.42	2.21	33	13.42	17.18	14.51	5.96	2.12
34	12.14	3.94	2.29	5.60	1.11	34	4.32	3.53	14.44	6.65	9.03
35	10.07	13.53	9.74	16.451	7.00	35	12.26	14.01	9.89	17.95	6.87
36	3.79	7.31	8.76	20.27	39.31	36	3.61	16.48	10.28	7.57	36.71
37	0.36	23.86	9.66	8.00	0.00	37	1.95	3.89	18.76	15.01	6.12
38	30.91	8.45	2.53	11.03	8.78	38	10.99	12.84	3.44	8.63	21.93
39	0.30	0.45	0.17	0.49	0.00	39	1.96	0.62	0.26	0.4	0.44
Total	100	100	100	100	100	100	100	100	100	100	100

Note: N.gen = Number of Generator; C.gen = Capacity of Generator; S.gen = Self generated electricity; PLN = Power purchased from PLN; NPLN = Power purchased from non-PLN sources

Source: BPS, Industrial Statistics 1985 and 1994

Information about the Energy/ Electricity Consumption

Several sources of information are available regarding electricity consumption in the manufacturing sector. First is information about the proportion of electricity consumed from PLN, non-PLN and self-generated sources. More detailed information is available about generators that firms themselves own, such as the total number of generators, generator capacity, level of production, and electricity sales. Also available is detailed information on fuel consumption. Table 9 focuses on the average firm and proportional share for 2-digit industries.

Table 9 shows a shift in total generators owned for the period 1985-1994. Several industries recorded significant change, including the textile, garment, and leather industry (ISIC 32), whose share in total generators jumped from 20.70 percent in 1985 to 35.66 percent in 1994. The share of the wood, bamboo and rattan (including furniture) industry also grew over the same period from 7.64 percent to 13.42 percent. The same period saw a drop in the share of generator ownership for other industries: the paper and paper products industry (ISIC 34) share fell from 12.4 percent to 4.23 percent, and the share of the manufacturers of fabricated metal products, machinery and equipment dropped from 30.91 percent to 10.99 percent.

In terms of generator capacity, this period saw a significant shift in the share of the total among manufacturing industries. The 1985-1994 period saw a shift in the way electricity was obtained. The food, beverages and tobacco industry is no longer the major consumer of electricity cap now worn by the paper and textile industries.

Electrical intensity for firms is represented by such variables as wages/Kwh and value added/Kwh. Table 10 shows that the food and beverages industry occupies the number one spot in terms of electrical intensity, followed by the machinery and equipment industry. The lowest elec-

Table 10. **Energy/Electricity Intensity of Manufacturing Industries, 1995**

ISIC	Wage/KWH	VA/KWH
31	1.07	11.46
32	0.41	2.07
33	0.47	2.70
34	0.18	1.39
35	0.44	2.95
36	0.17	0.99
37	0.08	2.06
38	0.92	8.67
39	1.43	5.07
Average	4.15	0.57

Source: BPS, Industrial Statistics 1995

Table 11. **Manufacturing Industries: Electricity Purchased and Generated (gwh)**

ISIC	1985		1995	
	Self Generated	Purchased from PLN	Self Generated	Purchased from PLN
31	9,768.7	290.5	1,081.6	1,405.3
32	1,985.6	676.9	1,899.0	4,406.9
33	1,605.9	37.5	1,419.2	816.7
34	457.0	147.4	1,458.3	1,091.9
35	194.7	433.1	1,189.9	2,044.9
36	1,751.6	533.7	1,065.6	1,461.0
37	1,931.0	2,106.3	965.7	1,821.8
38	505.7	290.4	311.5	1,388.3
39	33.5	12.9	26.6	79.4
Sum	19,986.7	4,528.7	9,417.7	14,516.2

Source : BPS Industry Statistic, 1985, 1995, calculated

trical intensity is attributed to the non-metal products industry.

Self-generated Electricity and Its Efficiency

Over the years electricity consumed by the industrial sector has accounted for a larger and larger portion of total final consumption. In 1975, for instance, this sector consumed just 30 percent of the total, rocketing to 56 percent by 1994. Although many large and medium-scale industries employ the services of PLN, most rely on self-generated electricity, as shown in Table 11.

Table 11 shows that electricity production increased between 1985 and 1994 only in the paper and chemical industries, both of which are relatively low electricity intensive in terms of VA per Kwh . For all other industries the amount of self-generated electricity fell. On a cumulative basis, the manufacturing industry generated around 20,000 Gwh in 1985, slipping to around 9,500 Gwh by 1995 an average

Table 12. **Manufacturing Industries: Electricity Purchased and Generated (%)**

ISIC	Self genr*/total (%)			Self genr/purchased		
	1985	1990	1995	1985	1990	1995
31	97	70	44	33.62	2.31	0.77
32	75	45	30	2.93	0.81	0.43
33	98	80	63	42.82	4.09	1.74
34	76	58	57	3.10	1.36	1.34
35	82	57	37	4.5	1.35	0.58
36	77	77	42	3.28	3.36	0.73
37	48	77	36	0.92	3.31	0.53
38	64	33	18	1.74	0.50	0.22
39	72	40	25	2.61	0.65	0.34
Average	82	64	40	4.4	1.8	0.65

Notes: Self-Genr = Self-generated of electricity by industry

Source : BPS Industry Statistic, 1985, 1990 and 1995, calculated

annual decrease in the region of 4.81 percent. In contrast, the amount of electricity purchaed from PLN rose sharply from just 4,500 Gwh in 1985 to 14,500 GWH in 1995. This translates as a 20.05 percent hike in electricity purchased from PLN each year.

In relative terms, the percentage of self-generated electricity plummeted from 82 percent of the total in 1985 to just 40 percent in 1995. What's more, dividing total self-generated electricity by total electricity purchased, indicates that in 1985, self-generated electricity was 4.5 times the amount of electricity purchased from PLN. By 1995, this figure had dropped sharply to 0.5 times.

The data in Tables 12 shows that in general PLN is unable to meet demand for electricity in the industrial sector. This is true not only in terms of the amount of electricity generated (Kwh), but also in terms of other factors, particularly distribution to industries in isolated areas not yet served by PLN. For this reason industries have decided to produce their own electricity, even though in terms of efficiency, this self-generated power is relatively costly compared to that produced by PLN in 1985 (see Table 13). Taking into acount outage costs however, makes the cost of self-generated electricity less expensive than PLN-generated power (Abimanyu, 1993).

As production of electricity by PLN increased, industry began substituting self-generated electricity with power purchased from PLN 36 percent of the total in 1990, rising to 61 percent in 1995. But this does not mean that industry no longer supplies its own power, since they use self-generated electricity during blackouts in order that the production process is not interrupted. As shown in Table 11, the proportion of self-generated electricity is falling, from 64 percent of the total in 1990, to 40 percent by 1995.

Input-Output Model For Unsupplied Electricity

The supply side model, with the output of the electricity sector specified exogenously, estimates the impact of an electricity outage on the economy. This is the cost to the economy of lost production arising from a decrease in the output elec-

Table 13. **Level of Eficiency of Self-generated and Electricity Purchased by Industry**

ISIC	Self genr/Value added			Purchased/Value added		
	1985	1990	1995	1985	1990	1995
31	4.18	0.22	0.07	0.12	0.09	0.09
32	2.06	0.37	0.14	0.70	0.46	0.33
33	2.18	0.53	0.23	0.05	0.13	0.13
34	1.90	0.73	0.41	0.61	0.54	0.31
35	1.25	0.49	0.12	0.28	0.36	0.21
36	3.85	1.58	0.40	1.17	0.47	0.55
37	3.37	1.41	0.17	3.68	0.42	0.33
38	0.41	0.09	0.02	0.24	0.17	0.09
39	1.07	0.20	0.05	0.41	0.30	0.15
Average	2.46	0.48	0.13	0.56	0.27	0.20

Source: BPS, Industry Statistic, 1985, 1990, and 1995, calculated

Table 14. **Impact of An Electricity Outage**

ISIC	Industries	1985 Red. 1 Rp.	1990 Red. 1 Rp.	1993 Red. 1 Rp.
31	Food, Beverage & Tobacco	-0.0685	-0.0723	-0.1155
32	Textile	-0.0314	-0.0835	-0.0661
33	Wood & Wood Products	-0.0324	-0.0220	-0.0219
34	Paper	-0.0089	-0.0362	-0.0205
35	Chemical	-0.0816	-0.0752	-0.1003
36	Non-metal Products	-0.0334	-0.0313	-0.0319
37	Basic Metal	-0.0457	-0.0757	-0.0849
38	Machinery & Equipment	-0.0742	-0.0989	-0.0896
39	Other Manufactured	-0.0027	-0.0027	-0.0033
	Total Impact to Industries	-0.3787	-0.4978	-0.534
	Total Impact Without Electricity Sector	-1.395	-1.434	-1.360
	Total impact of one Rupiah reduction in Electricity throughout the economy	-2.395	-2.434	-2.360

Notes: Red = reduction

Source: BPS Indonesia Input-Output Table, 1985, 1990 and 1993, calculated

tricity. This cost will indicate the maximum amount that should be paid to improve reliability. Table 14 shows the results of one rupiah change in electricity output. The impact on industrial sector rose from Rp 0.38 in 1985 to Rp 0.53 in 1993. This indicates that the industrial sector in Indonesia is demanding more and more electricity for its production process. A fall in output of the electricity sector what in turn becomes an input of the production process in the industrial

Table 15. **Impact of One Rupiah Decrease in Primary Input Multiplier**

ISIC	Industries	1985 Red. 1 Rp	1990 Red. 1 Rp	1993 Red. 1 Rp
31	Food, Beverage & Tobacco	4.84	1.26	1.28
32	Textile	2.12	1.89	1.76
33	Wood & Wood Products	1.33	1.49	1.50
34	Paper	1.59	2.81	3.06
35	Chemical	5.36	2.32	2.53
36	Non-metal Products	2.4	2.37	2.47
37	Basic Metal	2.66	3.87	4.24
38	Machinery & Equipment	6.8	2.30	3.22
39	Other Manufactured	1.25	2.58	2.71
	Total	28.36	20.89	22.77

Source: BPS, Indonesia Input-Output Table, 1985, 1990 and 1993, calculated

sector means losses reported, or ever increasing costs incurred as a result of this drop in power.

Table 14 also shows that in 1985, the greatest impact of a drop in electricity sector output of Rp 1 would be felt by the chemical industry (35), causing output of this industry to fall Rp 0.084. In 1990, the machinery and equipment (38) was the industry most affected, at Rp 0.099. The position shifted again in 1993 to the food and beverages industry (31), with a drop in output of Rp 0.12. Seen in conjunction with the electricity intensity, and the means of production and type of output, and the role played by electricity in each, as well as growth of the industry itself, this shift in impact over the years is rather significant.

The overall impact of a Rp 1 drop in electricity output on the economy (excluding the electricity sector), is also rising from Rp 1.39 in 1985, to Rp 1.43 in 1990, dropping back again to Rp 1.36 in 1993. Overall, a one rupiah decrease in electricity output would have meant a drop in GDP of Rp 2.39 in 1985, increasing to Rp 2.43 by 1990. This result supports the results of previous analysis concerning the increasing role of electricity in the industrial sector, and the major contribution of the industrial sector to GDP in Indonesia.

Results of the analysis above show that the main use of the input-output technique is in differentiating the impact/cost of electricity blackouts on the economy as whole, and on individual industries on a national and sectoral basis.

The following approach (electricity as a primary input) is used to estimate the impact of a capacity shortage, by aggregating rows $(I- A_2)^{-1}$ for sectors 31 through 39. This input multiplier shows a shift in total sector output to *i* with a one rupiah change in electricity. Table15 presents input multipliers for each industrial sector, which show that in 1985 the impact of capacity shortage was felt most by the machinery and equipment industry (38). In 1990 and 1993, the base metals industry (37) felt the largest impact.

The impact on these two industries is of great interest since they are very closely connected output of the base metal industry (37) provides input for the machinery and equipment industry (38). The chemical industry's dependence on electricity is understandable since the nature of its production demands a continuous source of electricity. These results are consistent with previous analysis which identifies the chemical industry, the machinery and equipment industry, as most affected by an electricity outage. The results of the analysis also show the unique position of the food industry in the Indonesian economy. According to the first model this industry suffers the greatest losses as a result of an electricity outage, while according to the second model, this industry does not have a large input multiplier.

Conclusion

This study shows the electricity demand and supply problems in the manufacturing industry in Indonesia. It shows that there is an imbalance between PLN's supply of electricity and industries' demand for electricity. PLN inability to meet industry demand results from high industrial growth, the low capacity factor of PLN power plants, and distribution to industries located in regions not yet served by PLN. In order to provide adequate, reliable power, industrial concerns rely on self-generated electricity. The contribution of self-generated electricity to total supply stood at around 40 percent in 1995.

According to the data presented, there is a significant decreasing trend in the contribution to total supply provided by industries themselves. Conversely, electricity purchased from PLN has increased sharply. This is reasonable since the value added ratio for industry-generated electricity (reflecting the price of industry-generated electricity) is higher than that for electricity purchased from PLN. This means that firms view PLN-generated power to be more reliable.

The impact of electricity blackouts on industry increases from year to year., This demonstrates that the manufacturing industry in Indonesia is using an ever increasing amount of electricity as input. As such, the costs which must be incurred from outages are also expanding, as a result of an interrupted production process. Behind this increase lies the shift in the role of self-generated electricity to PLN generated power if an electricity outage occurs at PLN, firms experience a power shortage, pushing up outage cost.

Outage costs remain high because industries continue to be wasteful in their use of electricity, so increasing their dependence on electricity (rising electricity intensity). Although PLN performance is improving in terms of meeting the demand of consumers, and in terms of reliability, this does not mean PLN is problem free. The challenge for PLN is to win sustained, and even greater, industry confidence by guaranteeing the availability and continuity of its electricity supply. This means more efficient, more professional performance on the part of PLN.

So, what needs to be emphasized is the importance of demand side management (DSM) on the part of PLN. Up to now, evidence suggests that PLN only considers how to generate enough power to meet demand. As a result, policy tends more towards the construction of new power plants, even though this supply bottleneck could be resolved by applying a strategy of price differentiation, and/or a conservation strategy. Through price differentiation, PLN could cut the very high level of demand for electricity at peak time. Applying a conservation strategy would mean that PLN would work towards improving the capacity factor of existing generators, to a cost efficient level. Only after implementing a mixed policy, and shortages still occur at peak time, should PLN consider building new power plants. And then only after considering other factors such as a change in the electricity market and consumers, both exisiting and potential. This would mean that the construction of new power plants would not be wasteful in terms of energy and cost, and perhaps would not oversupply because of a failure on the part of PLN to predict shifts in consumer and market behavior. The root of all PLN related policy implications lies in a shift in the orientation of PLN to a professional corporate concern. DSM does not mean that PLN will not enjoy the benefits of conservation and economizing, but rather will confer two advantages simultaneously. *First*, market and product expansion will attract new customers, and *second*, the "indirect" benefits of environmental conservation and energy economizing policy will ensue. And this means that PLN will still function as an "agent" of development.

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